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HW201/ HW101 SUPERCAPACITOR
Datasheet Rev 1.0

Features

- High capacitance (350mF @ DC)
- Low ESR (120mΩ @ step change in current);
- High peak current
- High pulsed power
- Thin form factor

Typical Applications

- High power LED Flash
- Improved audio performance
- Automatic Meter Reading
- PC Cards, Compact Flash Cards & USB
- Load levelling for PDAs & cell phones
- Power support during battery contact bounce

Electrical Specifications

Table 1: Nominal Characteristics

Device	Nominal Capacitance[1]	Nominal ESR[2]	Tolerance about nominal value	Footprint	Height	Weight[3]
HW201F	350mF	120mΩ	±20%	28mm x 17.0mm	2.5mm	1.5 gm
HW101F	700mF	60mΩ	±20%	28mm x 17.0mm	1.20mm	0.75 gm
HW201G	Electrically identical to "F" products. Double sided tape added to underside for more secure mounting, refer to Fig 13, optional adhesive tape.			28mm x 17.0mm	2.6mm	1.55 gm
HW101G				28mm x 17.0mm	1.3mm	0.80 gm

[1]At 23ºC DC. [2]Measured using a 0.5A step in current @ 23ºC. [3]To the nearest 50mg

Table 2: Absolute Maximum Ratings

Parameter	Name	Conditions	Min	Max	Units
Terminal Voltage	Vc			5.8	V
Temperature	T		-40	+85	°C

Table 3: Electrical Characteristics

Parameter	Name	Conditions	Min	Typical	Max	Units
Terminal Voltage	Vc				5.5	V
Leakage Current[3]	I_L	5.5V, 23°C 72hrs		1.0	2.0	μA
RMS Current[4]	I_{RMS}	23°C			3.6	A
Peak Current[5]	I_P	23°C			>30A	A

[3]After 72hrs @ 4.5V at 23°C. [4]Continuous charge and discharge for 2min operation. [5]Single pulse, non repetitive current.

Definition of Terms

In its simplest form, the Equivalent Series Resistance (ESR) of a capacitor is the real part of the complex impedance. In the time domain it can be found by applying a step discharge current to a charged capacitor as in figure 1. In this figure the supercapacitor is pre-charged and then discharged with a constant current pulse (I). The ESR is found by dividing the instantaneous voltage step (ΔV after 50µsec from start of current pulse) by I. The instantaneous capacitance (C_i) can be found by taking the inverse of the derivative of the voltage and multiplying it by I. The effective capacitance (C_e) is found by dividing the total charge removed from the capacitor (ΔQ_n) by the voltage lost by the capacitor (ΔV_n). Note that ΔV, or IR drop, is not included because this is the voltage drop due to ESR. C_e shows the time response of the capacitor and it is useful for predicting circuit behaviour in pulsed applications.

In the example of Fig 1, using an HW201, 4.49V – 4.38V = 110mV, I = 1.03A, so ESR = 0.11V/1.03A = 106.8mΩ. Similarly for $C_{effective}$ at 500µsec ΔV_n = 4.38V – 4.35V = 0.03V, Δt_n = 500µsec, and I = 1.03A. Therefore, C = 1.03A X 500×10^{-6}s/0.03V = 17.2mF.

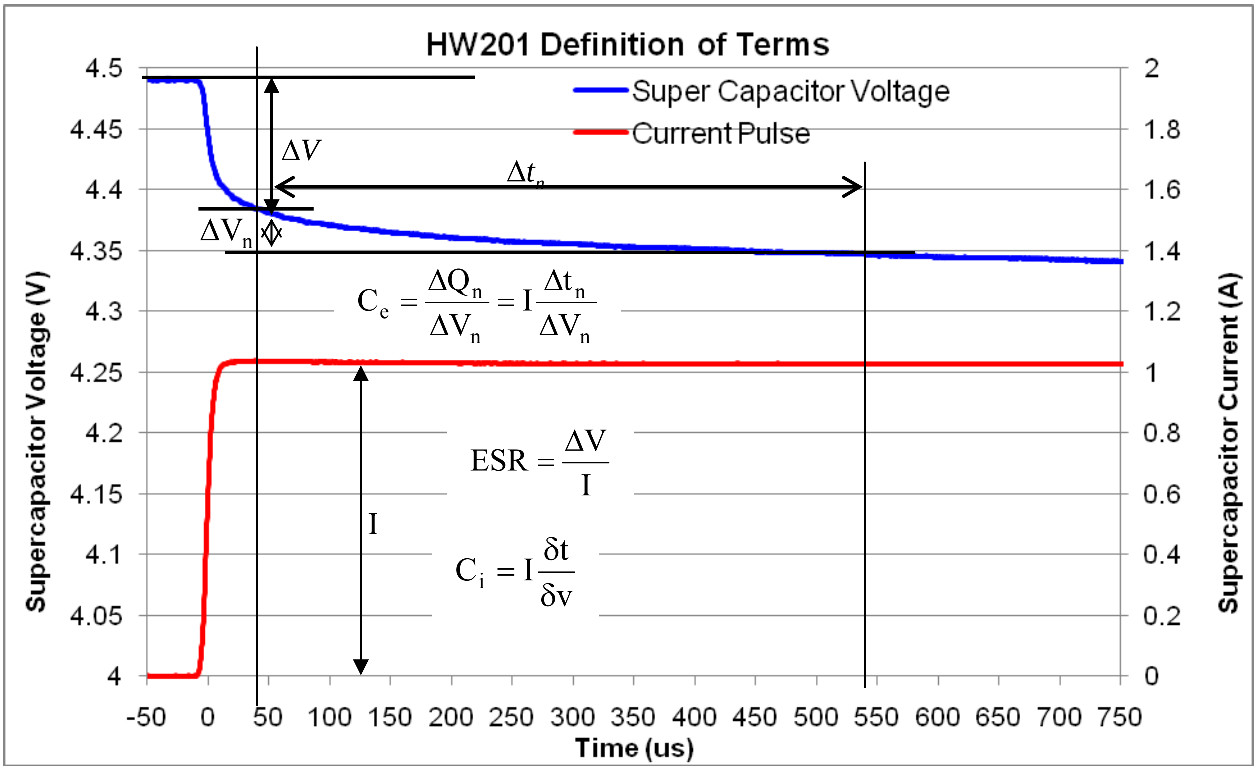

Figure 1: Definitions for Effective Capacitance, Instantaneous Capacitance and ESR

DC Capacitance

CAP-XX measures DC capacitance by charging the supercapacitor to 4.5V then disconnecting the supercapacitor from the source, and applying a constant current discharge of 100mA. At Cap-XX, capacitance is measure using the time taken for the voltage to drop from 3V to 1V, so C = 100mA x (time taken to drop from 3V to 1V) / 2V.

In the example of Fig 2, for a ΔV_n = 3.0V – 1.0V = 2V, the corresponding Δt_c = 11.0 – 4.0s = 7.0s. C = I X $\Delta t_c/\Delta V_c$ where I = 0.10A, therefore C = 0.10 x 7.0s /2.0V = 350mF.

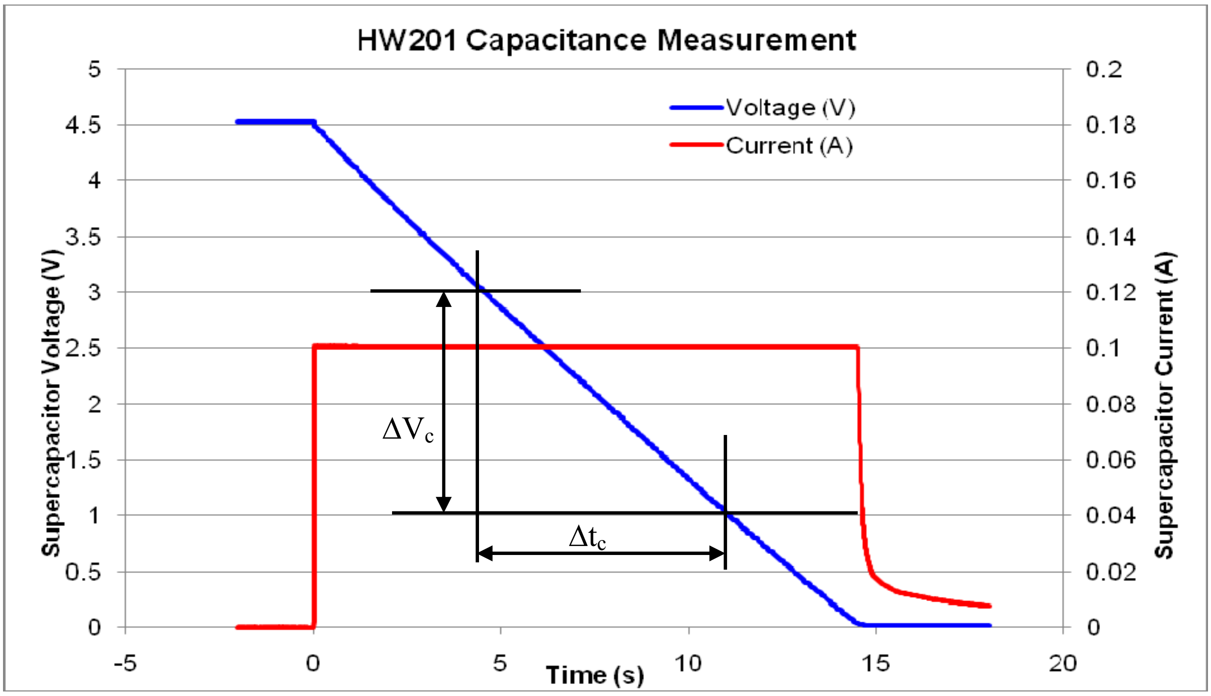

Figure 2: Measurement of Capacitance

ESR Measurement

CAP-XX measures ESR by measuring the voltage drop across the supercapacitor when a current step is applied to a supercapacitor. The supercapacitor is first charged to 4.5V then disconnected from the source, and finally the current step applied and the voltage drop after 50µsec is measured. The 50µsec delay allows time for the current pulse to settle before the measurement is made.

In the example shown in Fig 3 below ΔV = 4.49V – 4.38V = 110mV and ΔI = 1.03A (load pulse), therefore ESR = ΔV/I = 106.8mΩ.

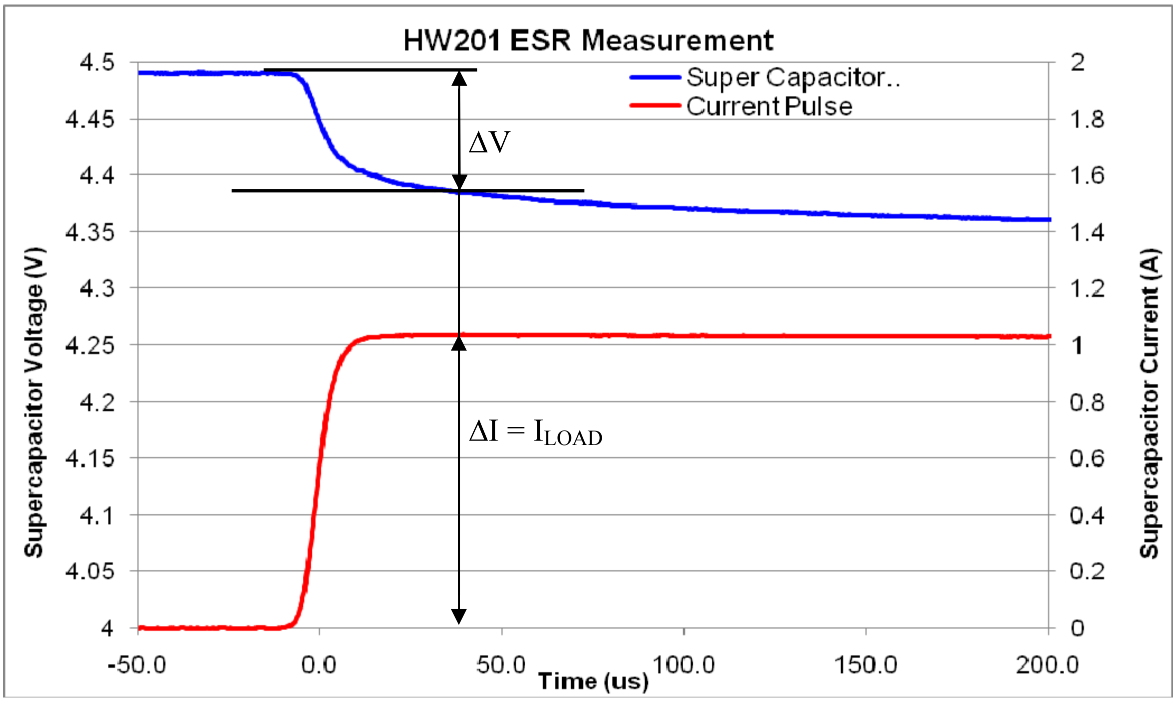

Figure 3: Measurement of ESR

Effective Capacitance

Figure 4 shows the Effective Capacitance for the HW201 @ 23°C. The supercapacitor was charged to and held at 4.5V until the current drawn by the supercapacitor dropped to less than 1mA. The supercapacitor was then disconnected from the source and a constant current discharge of 100mA was applied. The capacitance was measured at different times during the discharge.

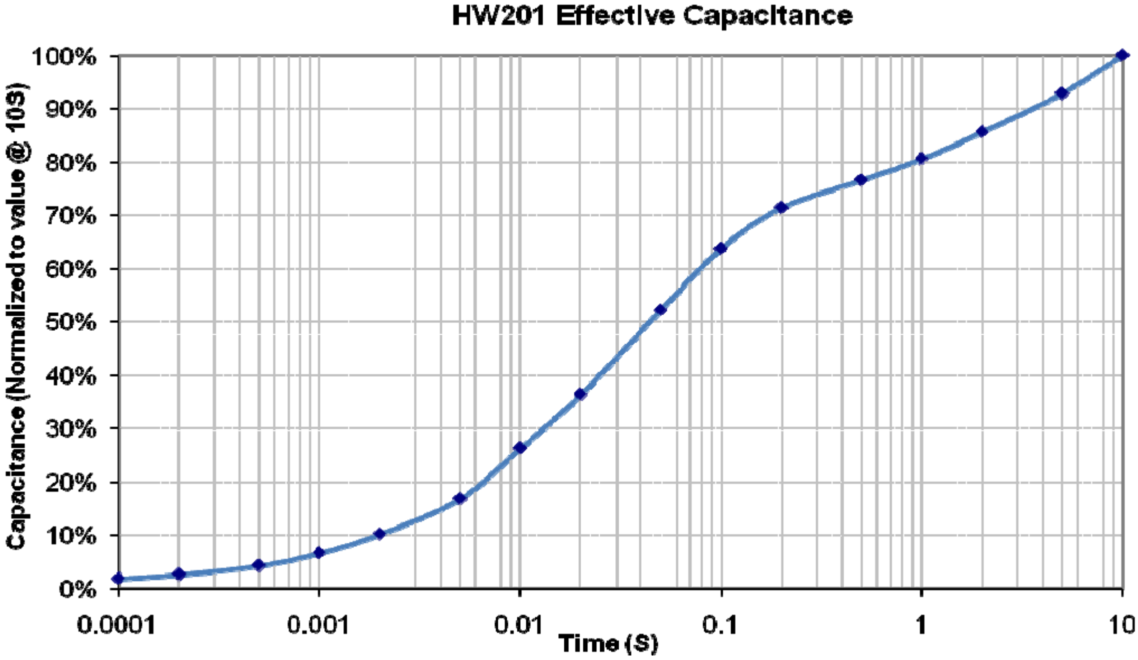

Figure 4: Effective capacitance at different times during the discharge.

Pulse Response

Figure 5 shows the voltage ripple for a class 10 GPRS pulse. A HW201 provides a 1.8A load pulse of 1.15ms duration @ 25% duty cycle and the source current is limited to 600mA. The low supercapacitor ESR and high effective capacitance result in the load seeing a voltage ripple of only 250mV. The 1.8A load current would consist of 0.6A current from the supply and the remaining 1.2A from the supercapacitor.

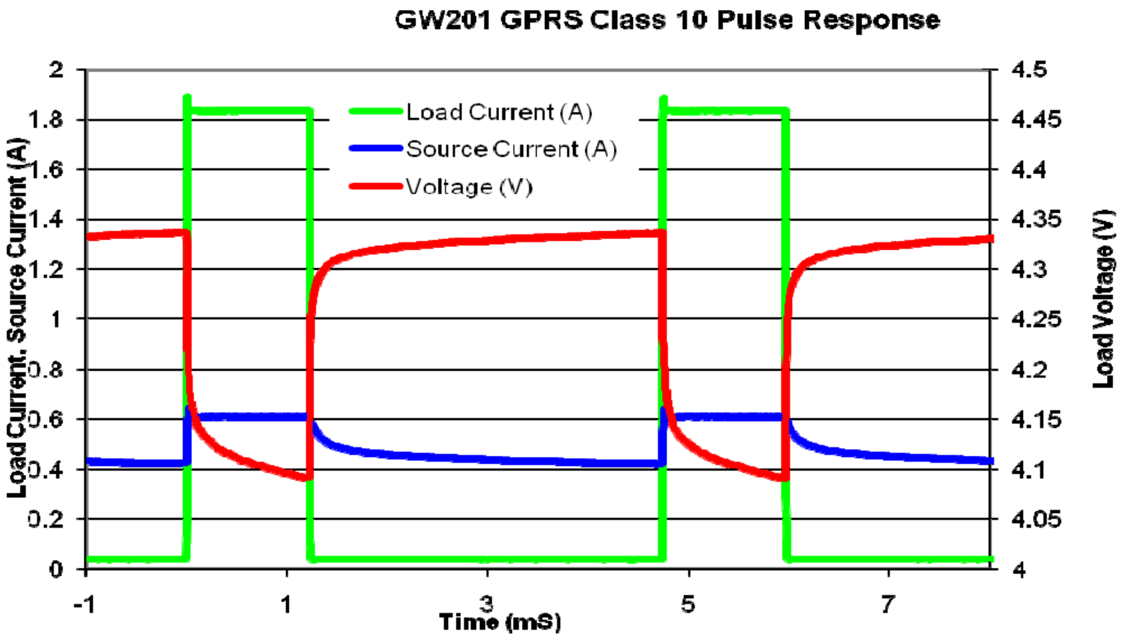

Figure 5: Class 10 GPRS pulse at 23C

Capacitance and ESR with temperature

Figure 6 and 7 below show normalized ESR and Capacitance respectively at different operating temperatures ranging from -40C to 85C.

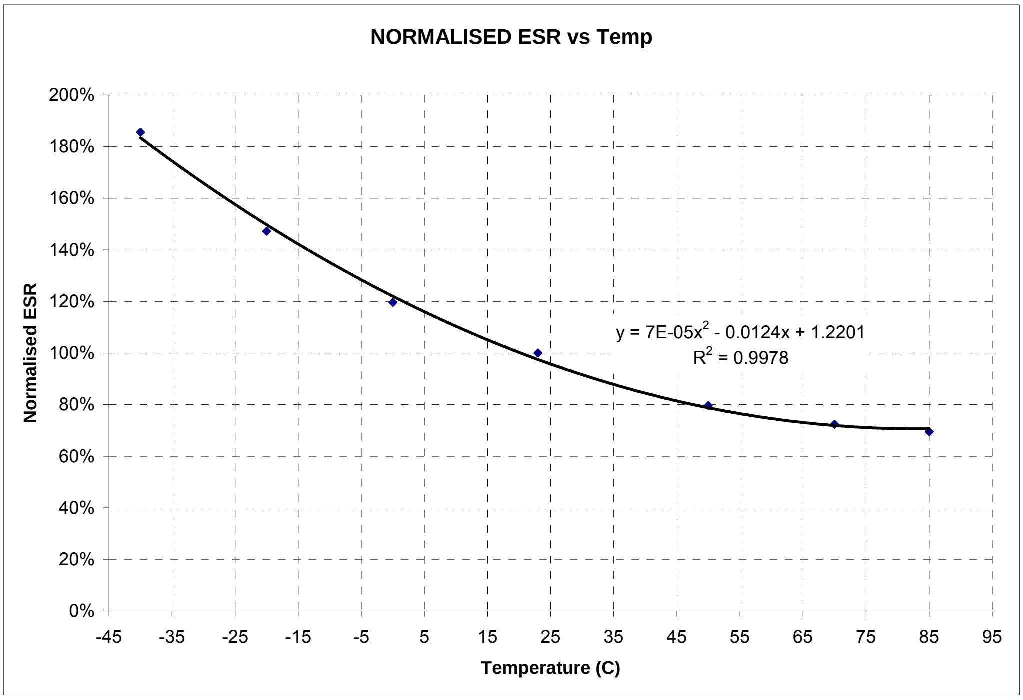

Figure 6: Normalised ESR at different temperatures

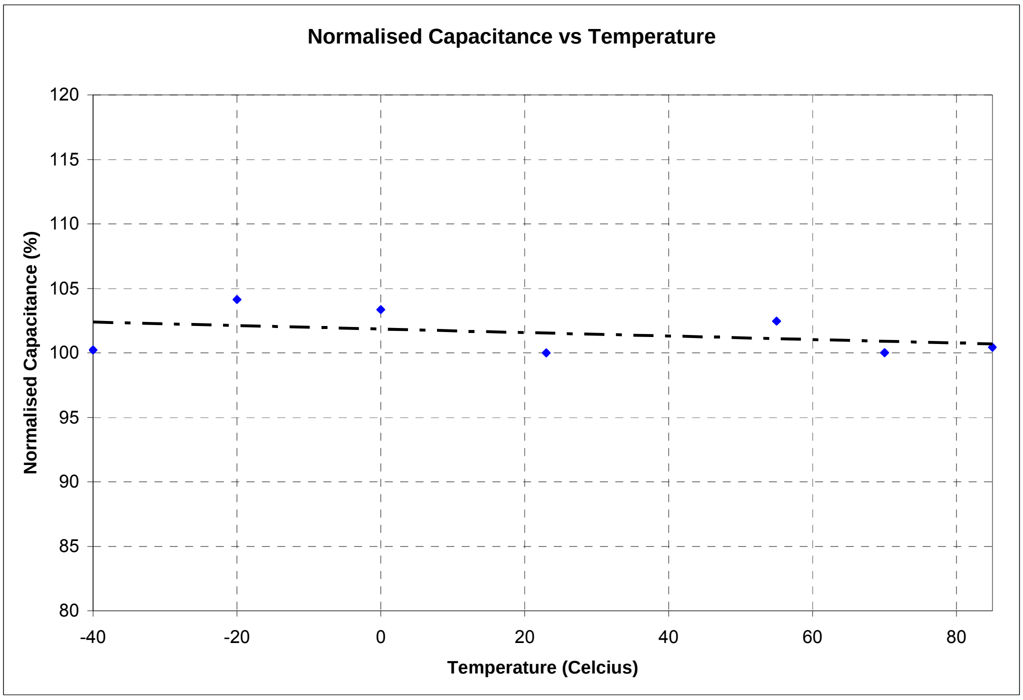

Figure 7: Normalised capacitance at different temperature

Frequency Response

Figs 8 and 9 show the supercapacitor behaves as an ideal capacitor until approx 1Hz when the magnitude no longer rolls off proportionally to 1/freq and the phase crosses -45°. Performance of supercapacitors with frequency is complex and the best predictor of performance is figure 4 which shows the effective capacitance as a function of pulse width. Inductance becomes significant above 20 kHz and is approx 100nH at 100 kHz and above.

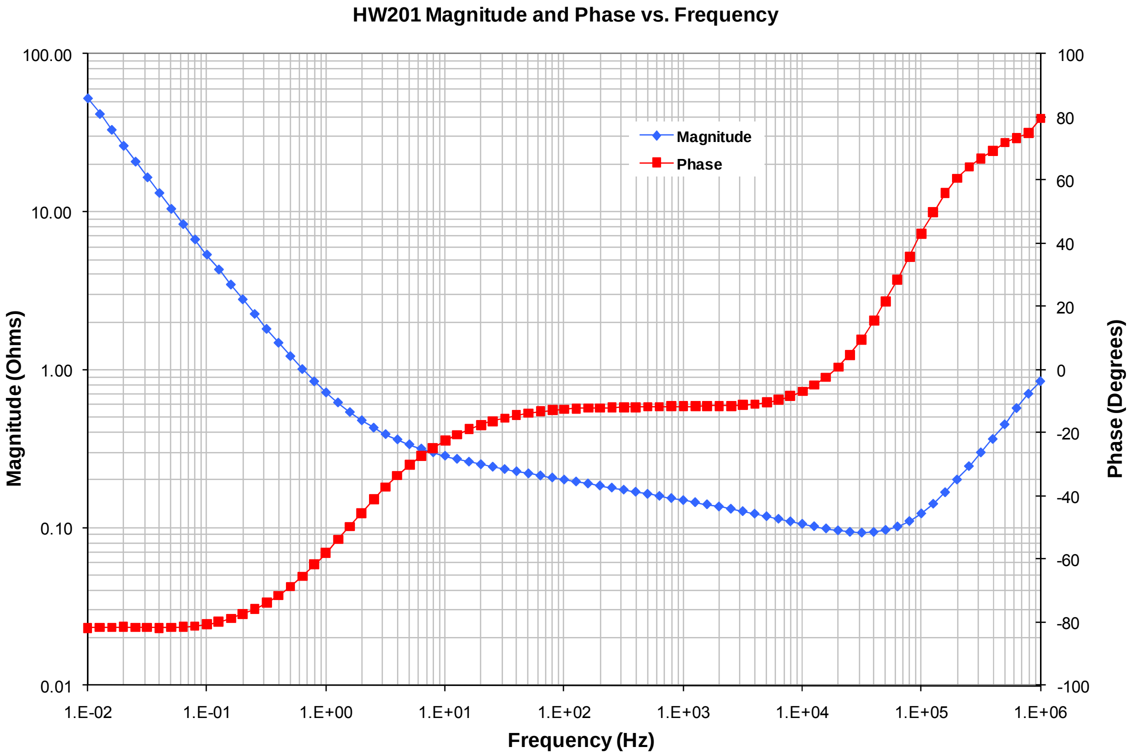

Figure 8: Frequency response of HW201 (biased at 5.5V with 50mV test signal)

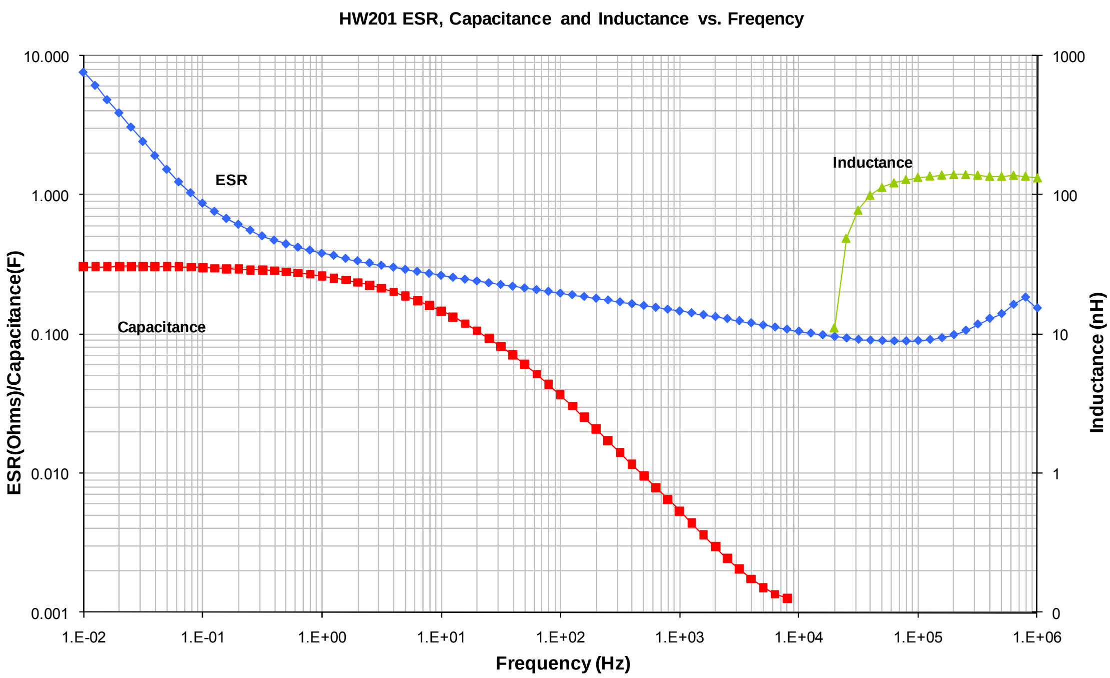

Figure 9: R, L and C components of HW201vs frequency

Spice Model

SPICE model of our supercapacitors can be found on our web site, www.cap-xx.com. Note that the spice model predicts freq and pulse response, not leakage current over the first 120hrs, prior to equilibrium being reached.

Leakage Current

Figure 10 shows how average leakage current decays with time. After 24hrs @ 23°C, leakage current has decayed to under 5μA and after 72hrs it has decayed to less than 2μA. This is because the capacitance in a supercapacitor is distributed. This means that although the final terminal voltage has been reached, the device still draws some charge current which continues to decay until it reaches a final equilibrium value of leakage current.

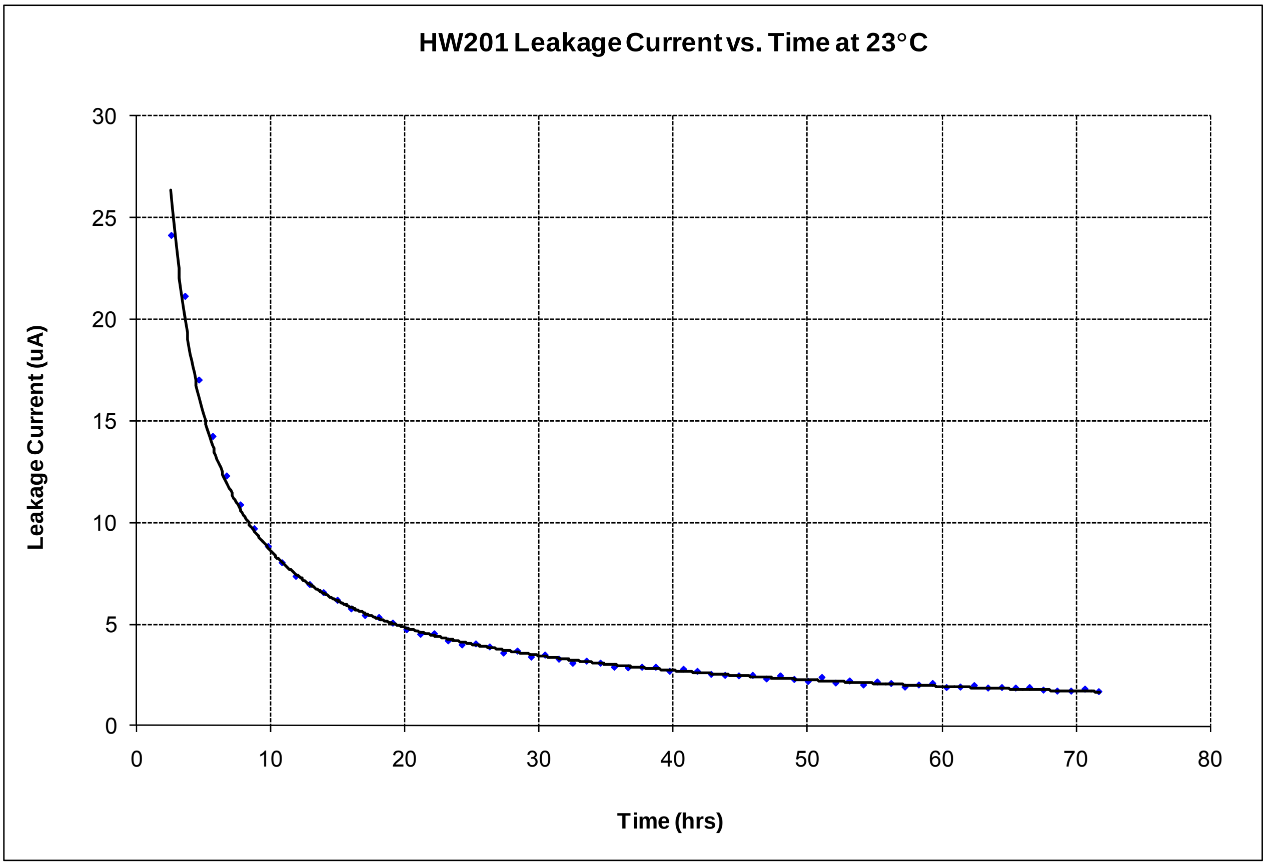

Figure 10: HW101 Leakage current vs. time

Charge Current

Supercapacitors require a minimum charge current before they behave as expected, i.e. they follow $\Delta V = I \times \Delta t / C$, for constant current charging from 0V. For a single cell of HW201 this minimum charge current = 50μA. Figure 11 illustrates the voltage over time for a single cell of the HW201 using 50μA, 100μA, 200μA and 500μA to achieve a final voltage of 2.75V.

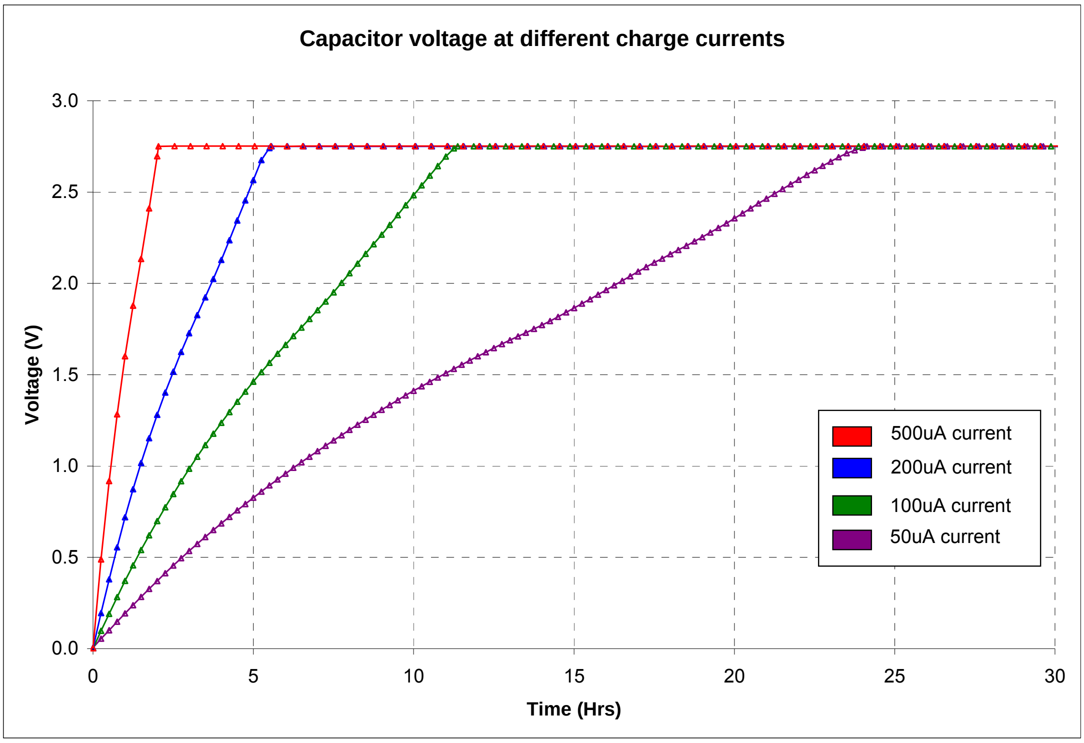

Figure 111: Voltage vs. Time for 50µA, 100µA, 200µA, 500µA charging currents at 23C

Soldering

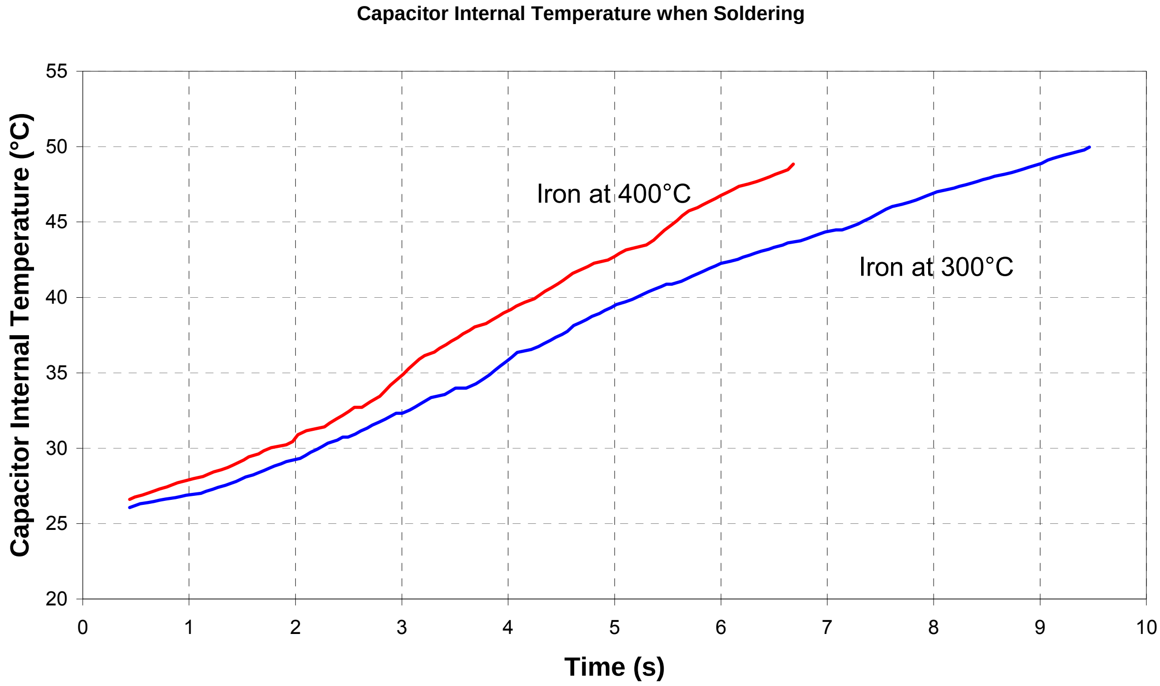

Figure 12: Capacitor temperature rise when soldering

The recommended maximum soldering time is 5 seconds when using an iron at 400°C in an ambient temperature of 23°C. Fig 12 shows the supercapacitor internal temperature increase over time as a soldering iron at 400°C is applied to one terminal.

Vibration

Tested to IEC68-2-6

Type	Sinusoidal
Frequency	55Hz-500Hz
Amplitude	0.35mm±3dB (55Hz to 59.55Hz)
	5g±3dB (59.55Hz to 500Hz)
Sweep Rate	1 Oct/min
No. of Cycles	10 (55Hz-500Hz-50Hz)
No. of Axis	3 orthogonal
Results	No electrical or mechanical degradation (adhesive not required)

Shock

Tested to IEC68-2-27

Pulse Shape	Half Sine
Amplitude	30g±20%
Duration	18ms±5%
No. of Shocks	3 in each direction (18 in total)
No. of Axis	3 orthogonal
Results	No electrical or mechanical degradation (adhesive not required)

Mechanical Drawings

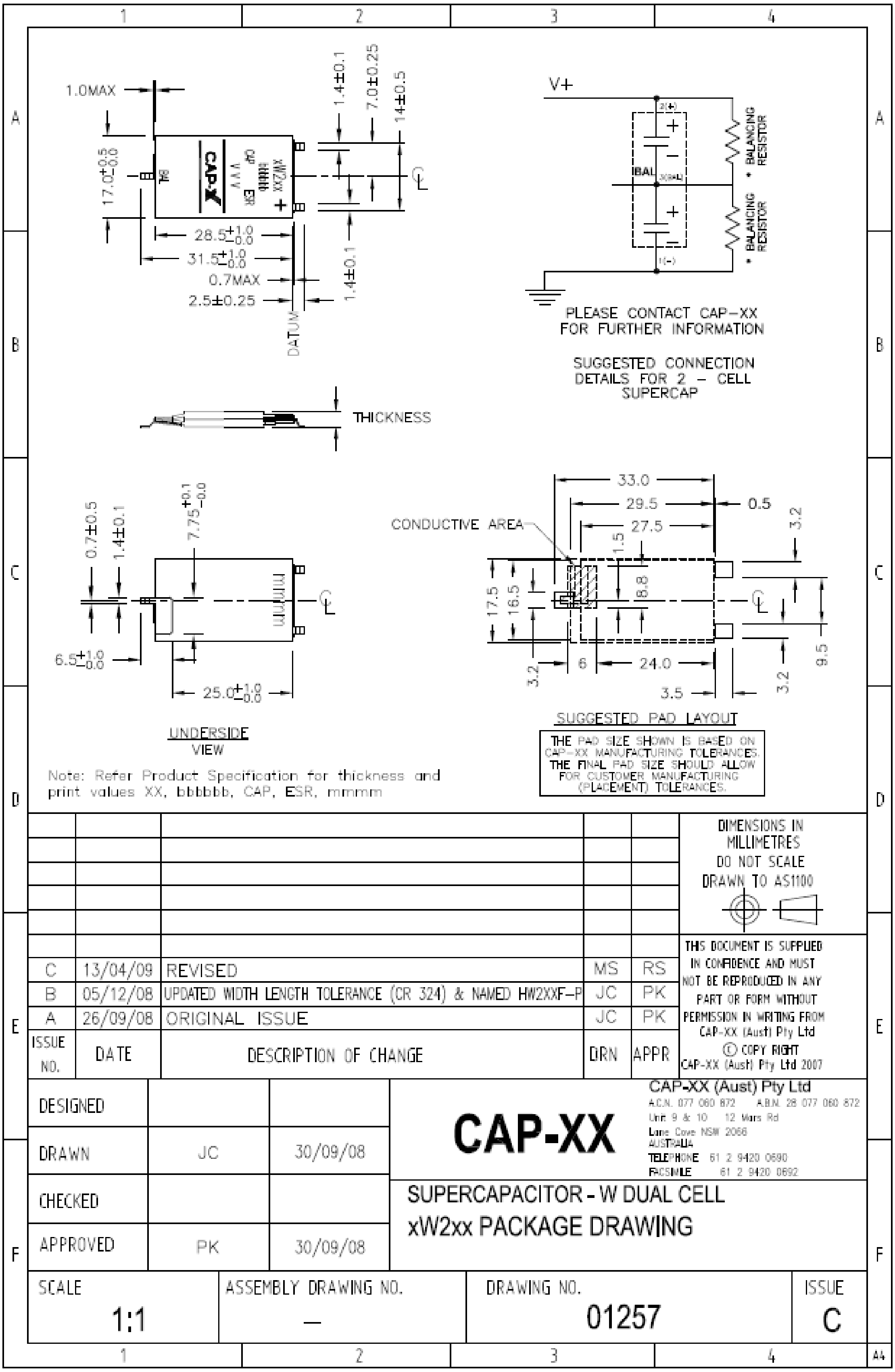

Figure 123: HW207 Product drawing

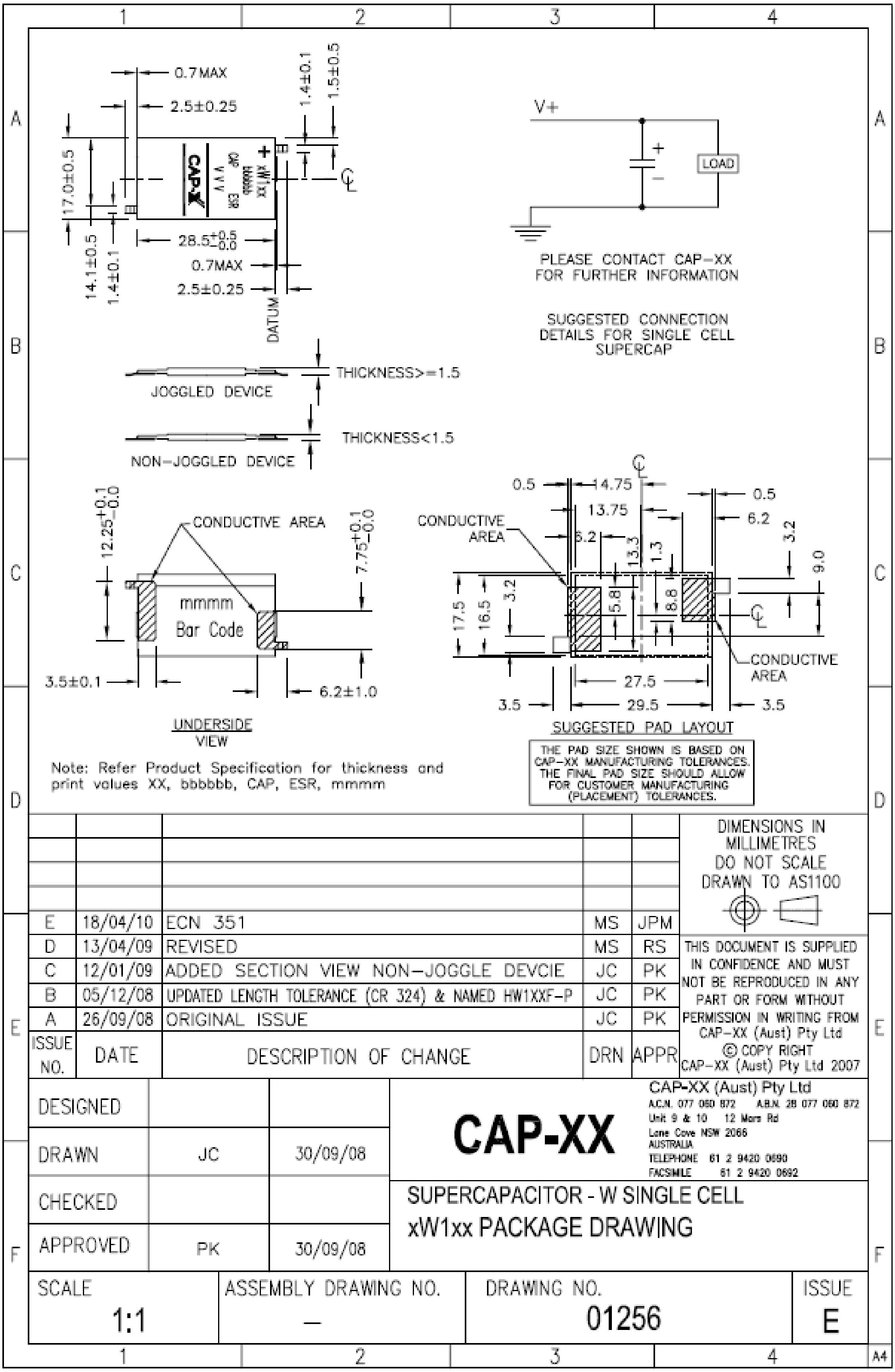

Figure 134: HW107 Product drawing

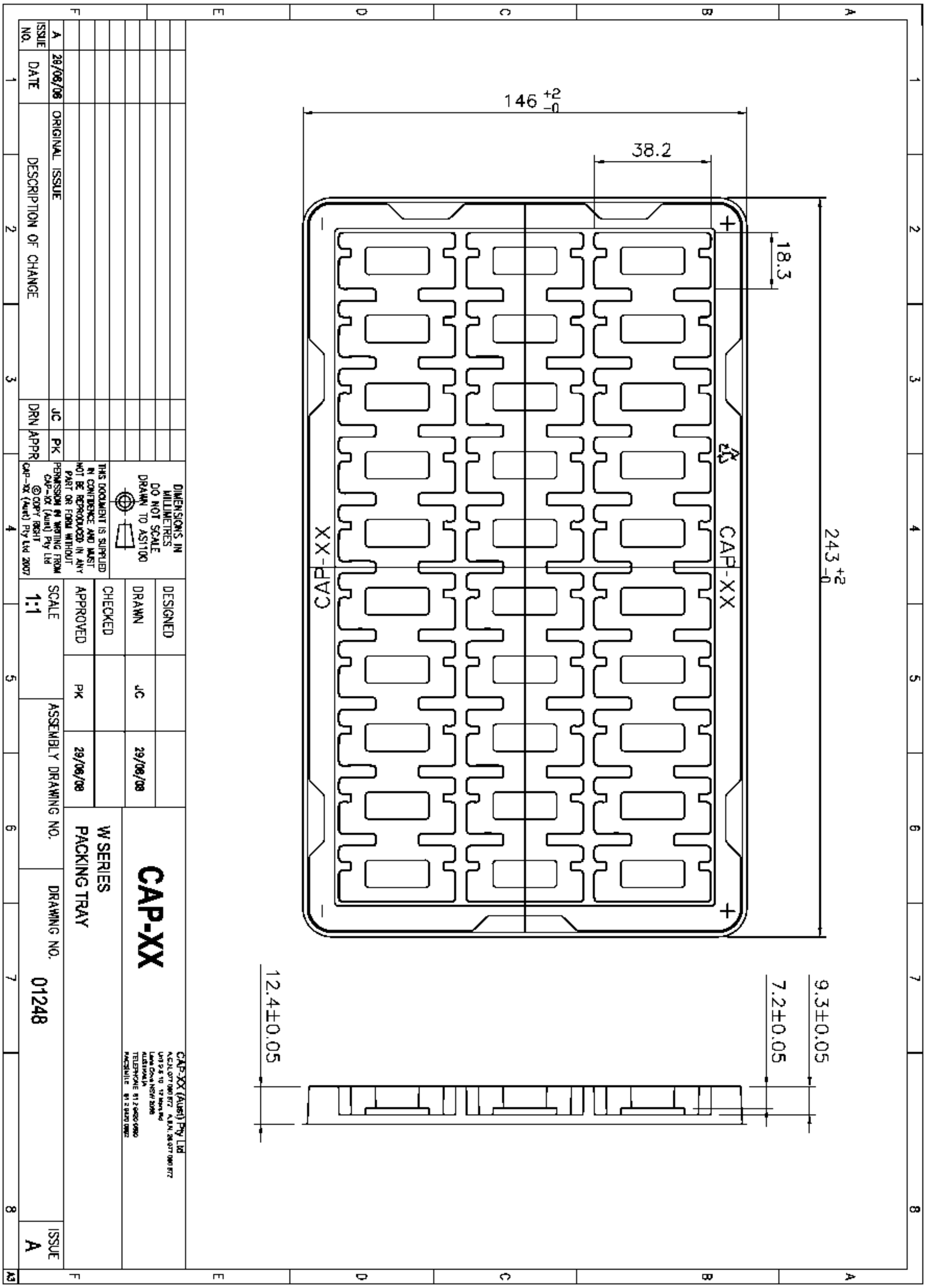

Figure 145: W Packaging tray